Reference	*[a9]* EMC File at Spectrum Sciences Institute
Country	*France*
Title	GSM - EMC considerations
Authors	*ETSI* Technical Report GSM 05.90, Version 4.0.0
Source	ETSI European Telecommunications Standards Institute February 1, 1993

This Report discusses results of laboratory evaluation of interference on hearing aids, cardiac pacemakers and domestic equipment. In the Scope it is stated that although the issue under study is GSM, the EMC considerations extend outside the GSM technology. Annex A-F and respective conclusions and recommendations are discussed below. ETSI proposes (Annex D EMC Considerations) that:

- Transmitters using AM or TDMA technologies be limited in radiated power to 1 W peak power for hand held devices and 5 W for vehicle mounted equipment, where the antenna is at a minimum hight of 1.5 m, located at least 0.75 m from the vehicle outline;

- generic immunity standards for all equipment be set at 10 V/m minimum; sectoral immunity standard for body worn audio equipment be set at 15 V/m minimum; and sectoral immunity standard for any "safety conscious" system be set at 25 V/m minimum.

The summaries of studies attached as Annexes to the brief main body of this Report are given separately in [a9]Annex A, [a10] and [a11].

Reference	*[a9]* Annex A EMC File at Spectrum Sciences Institute
Country	*United Kingdom*
Title	A Summarised Report on Measurements Techniques Used to Investigate Potential Interference From New Digital System
Authors	n/a
Source	Department of Trade and Industry Radiocommunications Agency (UK) Annex A to *ETSI* Technical Report GSM 05.90, Version 4.0.0, February 1993

The experimental data obtained in work by the Department of Trade and Industry Radiocommunications Agency (UK) presented in Appendix A to ESTI Report shows clearly that interference manifesting as "audible, annoying" demodulated sound can be detected for broad range of modulations used in their experiments.

Experiments had been set up to investigate subjectively the effects of modulation on perception of interference generated by 900 MHz 5W GSM system at two distances from a hearing aid wearer, 1 metre and 10-20 centimetres. In the first experiment the the pulse repetition frequency was set to 220 Hz and the duty cycle was 1 : 8. Further a comparative test on AM and Pulse transmissions was conducted. The RF signals were generated in a TEM cell. Interference was examined for a broad range of duty cycles (from 32 : 1 to 1 : 32), pulse repetition frequencies (from 10 Hz to 3 kHz) and modulation depth (from 10% to 100%).

In final conclusion, the DTI/RA study stipulates that it is a peak value of RF field strength of a carrier that is a dominant parameter responsible for EMC problems. Objective and subjective studies were carried out on several hearing several hearing aids, mostly "behind the ear" type (examples are given but exact number of hearing aids is not provided). Various degree of interference was identified. Number of variables introduced in the experiments make it difficult to draw quantitative conclusions. Subjective investigations showed better results than objective studies. Objective studies showed larger spread of results for induction coil mode than for the microphone mode. Attempts were made to improve hearing aid immunity by metallizing the enclosure (shielding). 3-fold improvement (10 dB) was recorded.

Reviewer	Dr. Jacek J. Wojcik, P.Eng., Spectrum Sciences/APREL
Reference	*[a9] Annex B and C (Annex B also listed as [a10])* EMC File at Spectrum Sciences Institute
Country	*United Kingdom*
Title	A GSM Interference Model
Authors	*Jon Short*
Source	British Telecom Laboratories - February 22, 1990 Annex B to *ETSI* Technical Report GSM 05.90, Version 4.0.0, February 1993

Modelling study at British Telecom Laboratory is described. It is shown that a hearing aid user would experience three seconds of interference every eight minutes while walking on a busy street in London and would be subject to 2.4% probability of interference while travelling on a commuter train. Other probability scenarios yielding much lower probability are proposed as well. This modelling is done with following assumptions: (1) GSM hand held transmitter has power of 2 W and a transportable unit has power of 8 W; (2) Free space pass loses not taking into account shielding and absorbing characteristics of surrounding (including people); (3) hearing aid is active all the time and its EM immunity is 3 V/m.

With the same assumptions (telephone RF power 2 W and hearing aid immunity 3 V/m) a statement is made (no modelling was done) that it was unlikely that a hearing aid user will be able to use GSM hand held terminals due to interference effects.

This study is an example of modelling which may be expanded for sets of new assumed parameters (RF peak power, immunity of hearing aids, directional radiation pattern, human body assumption, etc.) when they are becoming known from numerous studies.

Reviewer	Dr. Jacek J. Wojcik, P.Eng., Spectrum Sciences/APREL
Reference	*[a11] Annex F to [a9]* EMC File at Spectrum Sciences Institute
Country	*United Kingdom*
Title	Summary Document on GSM-TDMA Interference
Authors	*F. Mellish*, L.Williams
Source	Radio Technology Laboratory (RTL) - July 1, 1991 Annex F to *ETSI* Technical Report GSM 05.90, Version 4.0.0, February 1993

[a11] Annex F to [a9]

This report proposes to use the CCIR (currently ITU - International Telecommunication Union) ranking of transmission impairments. Authors use data from other studies, and set a "reference" impairment to CCIR grade 3.5 as acceptable. Data is taken from studies done by RTL, BT (UK), PTT (Netherlands). Discussion is given on distances at which interference may be expected at hearing aid immunity level of 3 V/m.

Paper concludes that users of hearing aids users (for hearing aids meeting current IEC standards) are likely to experience some interference from GSM mobiles (2 - 8 W) in close proximity and that they will not be able to use any of above systems themselves. The distances at which the assumed criterion of the CCIR Grade 3.5 will be met are 1.4 metre for a 2 W telephone and 2.8 metres for an 8 W telephone. For a 0.25 W DECT system the corresponding distance is 0.5 metre. No extrapolation is made for a 0.8 W nor 0.6 W telephones.

Reference	*[a14]* EMC File at Spectrum Sciences Institute
Country	*Australia*
Title	Possible Interference and Health Effects Associated with GSM Mobile Phones
Authors	*Ken Joyner*
Source	Telecom Research Laboratory date not available

It is a discussion paper prepared for Australian GSM MoU Committee.

Electromagnetic interference on various equipment: medical, automotive, domestic electronics and hearing aids, is reviewed. It is shown that all equipment may be affected by the mobile phones under certain conditions.

This report assumes that hand held GSM phones are operating on peak power of 2 W and transportable equipment operates at peak power of 8 W.

In case of equipment with an audio output "the most noticeable EMI effects are generation of a 217 Hz tone on audio outputs." The reports suggest that the distance at which EMI interference with domestic electronic equipment occurs is less than 2 m (for 2W telephones) and 6m (for 8 W telephones). The most susceptible hearing aids are the behind the ear type (BTE) and interference was reported up to "20 m from an 8 W transportable unit while the best ITE aid has an EMI radius of some 20 cm from the 2 W hand held GSM phone."

This paper is a "warning" presenting selected statements only and does not offer any conclusions.

In the section "Nature of Transmission from GSM Mobile Telephones" the authors are limiting the scope of their analysis (and experiments) to a 900 MHz system with telephones transmitting power of 2 Watt for hand held unit and 8 Watt for transportable unit. "The corresponding average power levels are 0.25 W and 1 W respectively." The statement that "The peak RF field strength close to the antenna of the mobile telephone can be quite high. At 10 cm from an 8 W transportable unit a peak RF field of 70-80 V/m has been measured." is based on attached reference provided by others *(see above)*. The timing of RF envelope pulses are given as 0.6 ms burst of RF energy *(should be 6.67 ms)* and 217 Hz repetition rate. The power and the "switching" are given as cause of interference: "The GSM system is a pulsed system with a higher peak power than the present analogue *(0.6 W)* mobile telephone system. This makes the GSM system much more likely to cause interference into electronic equipment which is apparently not affected by analogue RF fields." *(It is believed that authors by "this" mean peak power, since the pulsing character is a cause of a buzzing symptom rather than the cause of interference)*

Selected electroacoustic characteristics of hearing aids (8) used in experiments were tested prior to subjecting them to a RF field. *(No monitoring of electroacoustic characteristics or other parameters of hearing aid was done during the RF exposure).* The criteria for selection of hearing aids are not reported.

Described experiments consisted of recording of noise and speech with noise outputs of hearing aid with and without exposure to RF "GSM-like" field. Detailed setup description is given. The coupling of hearing aid to an ear simulator is done with a plastic tube to decrease effect of RF field distortion by the metal body of the ear simulator. The error in acoustic response caused by the tube arrangement is shown for one hearing aid for two sound levels at the output. The difference of responses due to the plastic tube is not taken into account in analysis of test results: "this change of response does not invalidate the measurements for the purpose of this investigation, since the bandwidth was not reduced significantly." *(The uncertainty, which could be as high as 10 dB, if taken into account, could significantly change concluding tables 1 and 2).*

Recordings from experiments described were analysed and data interpreted in two tables (Table 1 and 2). The immunity of the hearing aids is shown to vary from 0.4 V/m to 32.3 V/m for the criteria used. "Table 2 shows the relative distances at which the 10 dB threshold is reached from a 2 watt GSM hand-held mobile telephone and from an 8 watt GSM transportable telephone." "... significant variations occur in the field strength depending on immediate environment (near field, reflecting, shielding and absorbing phenomena), however the estimated values rank the aids correctly and give a realistic indication of the range where interference occurs."

The discussion in section "Interfering Mechanism" indicates weak areas in the hearing aid apparatus which may be responsible for susceptibility and further in the section "Remedies" feasibility of various approaches (filtering and shielding) to improvement on hearing immunity on existing units and in new design are presented as viewed by authors.

Conclusions are predicting that "widespread of the new GSM mobile telephones may make existing hearing aid useless for much of the time" *(meaning time or number of hearing aids - it is not clear)*, and warns that "Unless there is a realistic design remedy, new hearing aids will be affected, but possibly to a lesser extent, since partial remedies seem to be possible." The need for co-operative work is stipulated in identifying problems and in search of short term and long term solutions.

Recommendations are made to keep all interested bodies informed "about the interference that may be caused to hearing aid users" and to "initiate co-operative work to look for suitable *(hearing aid)* design solutions."

The scope of the report does not expand analysis of RF interference (EMI) beyond the symptoms caused by GSM modulation characteristics nor discusses possible symptoms (or lack of hearing aid users recognisable symptoms) in other modulation technologies. The scope of discussion of experiments does not look at scenarios where lower power transmitters are used in GSM service.

Reference	*[b28]* EMC File at Spectrum Sciences Institute
Country	*New Zealand*
Title	Digial Cellphones & Interference with Hearing Aid Users
Authors	*Anne Greville* Ph.D., Shanon Orr Bsc Dip. Aud
Source	National Audiology Centre August, 1993

This report describes a subjective study carried out in New Zealand on. Selection of subjects, 29 adults wearing hearing aids, was balanced with respect to age, sex, hearing impairment and type of hearing aid used. Two telephones were used in the study: GSM (Orbitel TMT 900) operating at three power levels (8 W, 2 W, and 0.8 W) and AMPS/DAMPS (Ericsson TR207) operating at power level 0.6 W. The pulse envelope repetition frequency was 217 Hz and 50 Hz respectively.

Subjects were sitting in a building with no reflections to electromagnetic field present. Field strength of signals generated by phones during experiments was measured with a dipole antenna. Subject signalled interference heard the same way as used in audiometric testing. The distance corresponding to the threshold of detectability and field strength were recorded. If the distance between the subject and the phone was less than 0.5 m, the field strength was not recorded because of overload and relative position errors. In a separate experiment, subjects rated interference, for male speech at an average conversational level of 65 dB(A), using a score rating provided. 16 of 29 hearing aids had telecoil, and experiment was carried out for both microphone and telecoil operation of hearing aid.

The threshold of detectability was less than 1m for all subjects when exposed to signals from 0.6 W telephone and 5 subjects could not detect interference at any distance. For 0.8 W and 2 W power the threshold of detectability was less than 1 m for 25 and 23 subjects respectively. For an 8W telephone the threshold of detectability less than 1 m was only for 16 subjects with 2 subjects which could hear some interference at 5 m. Analyses offered by authors indicates no significant difference between microphone and telecoil operations of hearing aids and no significant difference between GSM and DAMPS types of phones - "apart from the over-riding impact of the different power available."

In the closing discussion authors suggest that it is not only the hearing aids immunity but also hearing abilities and the auditory environment of the hearing aid user need to be considered. It is suggested that the immunity level of 3 V/m proposed by European Community electromagnetic compatibility directives is not adequate and should be increased to higher level of 7 V/m or 10 V/m. In closing remarks authors recommend further studies and information dissemination on measures to eliminate the problem of interference.

Reference	*[a18],[a19],[a20],[a21],[a22],[a23],[a26],[a27],[b4],[b6]* EMC File at Spectrum Sciences Institute
Country	*Canada & USA*

[a18]	**Title**	Working Party - DCT/HAC
	Authors	*Bob Corey*
	Source	n/a
[a19]	**Title**	Wireless Access Equipment and Hearing Aid EMI
	Authors	*L. Thorpe*
	Source	n/a - November 25, 1992
[a20]	**Title**	Subjective Assessment of CT-2 Interference to Hearing Aids
	Authors	*Bob Corey*
	Source	Department of Communication - January 21, 1993
[a21]	**Title**	Susceptibility of Hearing Aid Devices to Radio Frequency Fields
	Authors	*Brian Kasper*
	Source	Department of Communication - January 21, 1993
[a22]	**Title**	EMI Interaction between the CT2 Digital Handset and Hearing Aids
	Authors	*H. Arndt*
	Source	Unitron - February 16, 1993
[a23]	**Title**	CT2 Digital/Cordless Telephone Study Hearing Aid Compatibility
	Authors	*H. Arndt*
	Source	Unitron - March 12, 1993
[a26]	**Title**	Considerations regarding Hearing Aid Compatibility of DCT terminals
	Authors	*L. Thorpe*
	Source	Northern Telecom / BNR - February 16, 1993
[a27]	**Title**	Wireless Access Equipment and Hearing Aid EMI
	Authors	*L. Thorpe*
	Source	BNR - November 25, 1992
[b4]	**Title**	Radio Frequency Immunity Requirements for Equipment Having an Acoustic Output
	Authors	*TIA/EIA*
	Source	TIA/EIA - December 1, 1994
[b6]	**Title**	TAPAC Digital Cordless Telephone Service Committee
	Authors	*S.B. Hahn*
	Source	The Canadian Hearing Society - February 5, 1993
[b7]	**Title**	Report on the Coupling of Telephones and Hearing Aids
	Authors	*J.J. Wojcik*
	Source	APREL Industrial Acoustics - November, 1983
[b8]	**Title**	Hearing Aids Compatibility, Fourth Draft PN-3399
	Authors	*Joint CSA/TIA/EIA Working Group*
	Source	CSA T-515 - May 30, 1995

HAC standards and Canadian Studies

[a18], [a19], [a20], [a21], [a22], [a23], [a26], [a27], [b4], [b6], [b7], [b8]

Hearing Aid Compatibility standards by CCITT, EIA, TIA, CSA, IEEE, FCC and IS(former DOC) are dealing with the issue of magnetic coupling in the scenario when a telecoil in hearing aid is sensing magnetic field around the telephone earpiece. The above standards define magnetic output from the telephone (no standard exists at present for a telecoil hearing aid). Wireless telephones are exempt by FCC and IS(DOC). New draft TIA/EIA/CSA standard [b4] may be adapted for any telephone, not only the wireline since the reference used is acoustic output rather than telephone line signals. Because of the introduction of the CT2+ system scheduled in Canada for 1993 the Department of Communications (present name Industry Canada) set up this Working Party to include digital wireless telephones in the CS-03 (interconnect) standard for Magnetic Output for Hearing Aid Compatibility.

CT2+ is a digital phone with the envelope pulse with repetition frequency of 500 Hz. The power of a transmitter in the hand held unit is 250 mW.

Work of this committee triggered several studies on the issue of interference between CT2+ and hearing aids. The statistical study conducted by Bell Northern Research [a19], [a26], [a27] showed that more co-operative work is required before such two devices could be coupled. Immunity of hearing aids to electromagnetic field is unknown and in many instances less than satisfactory. Further, the same study, in its conclusions, predicts that Canada may become a "dumping" place for hearing aids with poor immunity if nothing is done prior to introduction of European Community directives on hearing aid EMC on 1st of January 1996. *(This may also be true for USA).*

In studies by Unitron [a22], [a23] showed not only examples of interference but also change of hearing aid compression characteristics due to exposure to an RF field [a23].

Studies performed by the Department of Communications [a20] and [a21] examined 17 hearing aids. Interference induced by actual CT2 phone [a20] was evaluated subjectively. In case of 9 hearing aids interference was noticeable at the distance of less than 1 centimetre. One hearing aid was immune to the CT2 RF signal even in close coupling. Subsequent objective studies [a21] identified immunity by placing hearing aids in the TEM cell. RF signal swept over frequency range 200 MHz to 1000 MHz was modulated with the CT2 pulse envelope, FM and $\pi/4$ DQPSK signals. The interference was detectable as distinct sound or baseline noise increase respectively. The degree of interference and frequency dependence of interference varies from one hearing aid to another.

As result of studies on electromagnetic interference further work on HAC (magnetic coupling) standard was suspended in context of IS CS-03. In the Canadian Hearing Society (CHS) submissions to the DOC [b6], the CHS proposes that each manufacturer should have at least one model of a telephone that will be modified to be compatible with hearing aids.

The need for different criteria for compatibility of wireless telephones and hearing aids was discussed by Canadian Working Party [a18], [a19], [b6].

The importance of amplification in the handset to match auditory environmental requirements of the hard of hearing is discussed in details by J.J. Wojcik [b7] and is reflected in current standards [b8].

Reference	*[b30]* GSM/EMI File at Spectrum Sciences Institute
Country	*Australia*
Title	Interference to Hearing Aids by the Digital Mobile Telephone System, Global System for Mobile Communications, (GSM)
Authors	*J. Ross Le Strange, Eric Burwood* - Engineering Section, *Denis Byrne* - Research Division, National Acoustic Laboratories; *Ken H. Joyner, Mike Wood* - Electromagnetic Compatibility Section, Telecom Research Laboratories;, *Grant L. Symons - Mobile Standards Section, AUSTEL*
Source	National Acoustic Laboratories, Sydney May, 1995

This is a continuation of the study reported on March 1993. (Ref [a14] reviewed previously). Several points of previous review are addressed by this new study. This study was conducted by a task group of the multidisciplinary technical committee. The study is limited to 2 W handheld GSM phones operating at 900 MHZ and having unwanted demodulated audible signals. None of the hearing aids measured had any signal processing resulting in non-linear gain (such as compression).

The objective investigation of immunity of hearing aids is improved by introduction of well controlled arrangement to achieve uniform electric field and to control angular positioning of hearing aid as one of variables. The measurements are addressing behaviour of hearing aids in far field scenario simulated in the waveguide. The near field measurements are not yet included in these objective tests.

The setup allowed very precise comparison of immunity for untreated (as received supplied by manufacturer) and treated (immunity improved by NAL) hearing aids. Possible improvements to hearing aids are implemented in laboratory and methods of improvements are described. Three methods of shielding and shunting capacitors are experimented. The results are indicating that techniques used as standard EMC treatment by other industries may work well with hearing aids in spite of mechanical packaging restrictions and compactness of these devices. Numerical values are reflecting experimental character of treatment. However, attenuation of interference of approximately 30 dB is measured.

The subjective experiments conducted within this study led the authors to the development of criteria, which would allow categorization of hearing aids with respect to their compatibility with the GSM telephones (for power levels used in Australia). It shows that, for 2 W GSM phone, hearing aids meeting requirements of 13 V/m will likely be usable at 1 metre distance in all situations. However, higher immunity levels, such as 50 - 58 V/m, are suggested for hearing aid compatibility with GSM 2 W telephone when used simultaneously on the same ear. *[If power level is less e.g., 0.6 W these immunity criteria may be much lower]*.

It is noted (p.26) that hearing aid immune to high RF field could be difficult to use due to acoustic feedback. When feedback was avoided, the hearing aid was successfully operating in the microphone mode but "could not be used for telecoil listening because a "buzz" occurred when the telephone was about 0.3 metre from the aid". This problem of potential low frequency magnetic coupling is not discussed further. In table 9 this hearing aid is classified as usable with telephone (Class 2) and acoustic level is ranked "not perceptible".

The criteria proposed by this report are supported with detailed discussion. However, the criteria are based on detection of audible interference ("The detection was the object of study") and to linear hearing aids in microphone mode. Effect of other modulations of RF signal were not included in this study. In the discussion on effectiveness of shielding on p.3 it is noted "even where the unwanted emission is modulated at frequencies outside the audio range, say ultrasonic, the principles still hold although instrumentation for measuring the demodulated interference would obviously need to suit the particular requirement".

In addition to suggested modifications and classification of hearing aids, the report offers suggestions to awareness to interference offered to users and modifications of the telephone.

Some requirements for telecoil mode of operation are extrapolated from the microphone mode with assumptions of specific equivalence between microphone and telecoil sensitivities. A note is provided that "Specifications and standards that use the *equivalent input referred magnetic field strength* must state the equivalence between microphone and telecoil sensitivities"

CURRICULUM VITÆ

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EXECUTIVE SUMMARY

Professional Engineer and Researcher. 34 years of active professional career, with Industrial, Academic, and Administrative experience;

- 31 years of proven research leadership and project management record in the fields of telecommunications, acoustics, electroacoustics, and electromagnetics (EMI, EMC, ESD, ELF, radio, RF shielding and grounding).

- 26 years of active participation in development of international and national standards, both voluntary and mandatory/regulatory

EDUCATION

Docteur en sciences appliquées, University of Liège, Liège, Belgium, 1972
M.Sc. Electronics Engineering, Technical University, Warsaw, Poland, 1964

EXPERIENCE

Industrial

Present President, Spectrum Sciences Institute

1995-present *Chairman and Scientific Advisor, APREL Inc.*
1981- 1995 *Founder, Chairman and President, APREL Inc.*

Research and development projects for industry and governments in the fields of acoustics, electroacoustics, telecommunications, and electromagnetics (EMI, EMC, ESD, EMP, ELF, radio, RF shielding & grounding).

Research and development projects for industry and governments in the areas of standards, calibration, testing and regulatory certification for Canadian and international markets.

Development of acousto-acoustic coupler assistive device for the hearing impaired (patent held).

Development of specialized products and development of standards, specifications, and design guidelines. Design of shielded facilities. Consulting on calibration, acoustics, and electromagnetics (including shielding and grounding).

Participation in national and international committees for developments of voluntary and mandatory standards. Chairmanships of various National and International standards committees.

Development of the Quality Compliance Institute (QCI).

1975-1982 *Manager, Bell Northern Research*

Development of telecommunication devices and systems. Research on acoustics and issues related to compliance and integrity of telecom products, including hearing issues.

Management of Acoustic Research Department. Project management of research and design projects. Participation in national and international committees for developments of voluntary and mandatory standards. Chairmanships of various National and International standards committees.

1970-1974 *Doctoral Fellow and Professor, University of Liège*

Research and development projects for industry with emphasis on telecommunications sector.

Management of industrial liaison programs. Management of research and development projects including definition of scope, time control and design of reporting method.

1963-1970 *Technical University of Warsaw*

Research and development projects for industry. Development of passive transducers and filters. Environmental control projects for small companies and large concerns including redesign of manufacturing processes flow. Design of industrial, academic and recreational facilities for acoustics and other environmental aspects.

Management of industrial liaison programs. Management of research and development projects including definition of scope, time control and design of reporting method.

1962-1963 *OMIG, Poland* (Manufacturer of Electronic Components)

Design of specialized test equipment.

Academic Experience

1975-present

Training courses prepared and given to personnel as well as seminars offered to industry on electromagnetics, acoustics, standards, calibration, and various design and regulatory compliance issues.

1970 -1974

Teaching at University of Liège on Acoustics and Electroacoustics. Supervising Master and Engineering theses. Preparing and delivering seminars to telecom industry.

1963 - 1970

Warsaw Technical University; Designing experiments for electronic laboratory. Teaching Electromagnetics, Acoustics and Electroacoustics. Supervising Master theses

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OTHER

Author of over twenty technical publications and several patents.

Fluency: English, French and Polish

Personal

Date of Birth: February 25, 1941
Married, one child
Clearance: Secret
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CURRICULUM VITÆ

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Warsaw Technical University; Designing experiments for electronic laboratory. Teaching Electromagnetics, Acoustics and Electroacoustics. Supervising Master theses.

PROFESSIONAL ASSOCIATIONS

Professional Affiliations

Member, Association of Professional Engineers of Ontario
Member, Institute of Electrical and Electronic Engineers

Committees/Associations

Founder and President, Spectrum Sciences Institute
Board of Directors, Telecommunications Research Institute of Ontario

Memberships:
Ottawa Carleton Research Institute, International Electrotechnical Commission (IEC), Canadian Standards Association, Canadian General Standards Board, Electromagnetics/Communications/Vehicluar Technologies Societies of IEEE, Armed Forces Communications and Electronics Association, Canadian Industry Tempest Program, International Standards Association, Acoustical Society of America

OTHER

Author of over twenty technical publications and several patents.

Fluency: English, French and Polish

Personal

Date of Birth: February 25, 1941
Married, one child
Clearance: Secret
Citizenship: Canadian

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- Handsets

Associated Services

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- Specifications
- Testing
- Training
- Calibration
- Shielding

Hearing Aid Compatibility -- Activities and Achievements -- Notes for Discussion

Involvement in Hearing Aid Compatibility issues and research:

Dr. Jacek Wojcik - since 1975
APREL Inc. - since 1981
Spectrum Sciences Institute -from 1995

Leading contributions and participation in:

IEC, CCITT P37/NSG12, CSA T515/TIA TR41.3, NAFTA CCT, IC/DOC CS03, etc.

Development of research tools:

Audiometer-Telephone Interface
Experimental hearing aid (used in subjective studies in joint project with Penn State University)
Flexible Standard Ear Pinna Simulator (proposed as a standard to IEC)
Telephone Magnetic Field Simulator (TMFS, used by Health Canada in standard for HAC)

Development of specialized devices:

Acousto-Acoustic Amplifier (sponsored by Bell Canada, 2 patents awarded; this coupler provides 17dB acoustic amplification with no whistling, and also provides magnetic field amplification)
Telephone Output Magnetic Measuring Instrument (TOMMI, device for mapping magnetic output from telephone)
H-ANT (H-field calibrator for the above)

R&D efforts now undergoing transfer to Spectrum Sciences Institute, of which APREL is founding member and laboratory resource.

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